HOOKWORM DISEASE AS RELATED TO INDUSTRY IN AUSTRALIA[1]

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In mines, hookworm disease is well recognized as an occupational disease. Long before the cause was known, it was observed that the "miners' anemia" of Central and Northern Europe was unmistakably related to the occupation of mining, for people who did not go underground were not affected.

Even above ground hookworm disease may be an occupational disease in parts of the tropics and subtropics, especially among agricultural workers. After measuring the degree of infection of many people in Brazil by determining the number of hookworms expelled by treatment, Smillie[2] has expressed the opinion that in the tropics and subtropics "hookworm disease is an occupational disease and is largely limited to soil workers."

There are occupations other than mining and tilling the soil which have at times been found to favor the spread of hookworm infection even in regions where surface conditions would normally be unfavorable to the spread of infection, such, for example, as tunneling and brickmaking. But we have no evidence that these two occupations have been responsible for hookworm disease in Australia, where the observations presented in this paper were made. We shall, therefore, consider mining and tilling

[1] Read before the second annual meeting of the Public Health Association of Australasia, Sydney, September 12 to 16, 1922. The Australian Hookworm Campaign, on the work of which this paper is largely based, is conducted with the support and under the auspices of the Commonwealth, states, and territories of Australia, and the International Health Board of the Rockefeller Foundation.

[2] Smillie, W. G., Studies on hookworm infection in Brazil, 1918–1920, Second Paper, Monographs of the Rockefeller Institute for Medical Research, No. 17, May 12, 1922, p. 30.

the soil, since these are the kinds of work most likely to favor the spread of hookworm disease in Australia and her island territories.

INVESTIGATION OF AUSTRALIAN MINES

In four states in Australia, South Australia, Queensland, New South Wales, and Tasmania, but not in Western Australia or Victoria, ancylostomiasis is a compensable disease, under Workers' Compensation Acts if contracted as the result of the occupation of mining. This recognition of hookworm disease as an industrial disease was apparently due solely to European experience and precedent and was intended as a precaution for the future, for when these acts were passed there was no definite evidence that any of the Australian mines were infested.

Representative mines have now been examined by the Australian Hookworm Campaign in all the states and in Papua. No hookworm infection was found in the coal or metalliferous mines investigated in Victoria, Tasmania, and Western Australia. In New South Wales, in over 1200 examinations of miners of the Newcastle-Maitland coal-fields, only 5 infected miners were found, 2 of whom had probably contracted their infection outside this region. Under the Technical Commission of Inquiry 3788 miners in the metalliferous mines at Broken Hill in New South Wales were examined for hookworm disease by a staff loaned from the Australian Hookworm Campaign. No hookworm disease was found.[3] In Queensland no definitely infested metalliferous mine has yet been discovered, but hookworm disease was found to be prevalent and related to the occupation of mining in the Ipswich and Burrum groups of coal-mines. In Papua considerable hookworm disease was found among native miners, but the occupation of mining had apparently not, as yet, increased the amount of infection above that of the natives of the same region who did not engage in mining.

[3] Report of the Technical Commission of Inquiry to Investigate the Prevalence of Miners' Phthisis and Pneumoconiosis in the Metalliferous Mines at Broken Hill, Department of Labour and Industry, New South Wales, 1921, Chapter VII, pp. 44 to 57.

TABLE 1

Examinations of miners in Australia and Papua for hookworm disease, up to September 1, 1922

	TYPE OF MINE	APPROXIMATE NUMBER OF MINES EXAMINED	NUMBER OF MINERS EXAMINED*	INFECTED WITH HOOKWORMS	PERCENTAGE INFECTED
South Australia:					
Wallaroo and Kadina	Copper	2	228	0	0
Moonta	Copper	1	26	0	0
New South Wales:					
Broken Hill group	Lead, silver, zinc	10	3,788	0	0
Newcastle-Maitland group	Coal	23	1,224	5	0.41
Queensland:					
Ipswich group	Coal	26	1,030	324	31.5
Burrum group	Coal	7	264	208	78.8
Mt. Morgan	Gold, copper silver	1	164	2	1.2
Baralaba	Coal	1	101	1	1.0
Blair Athol	Coal	1	90	0	0
Gympie	Gold	1	117	0	0
Western Australia:					
Kalgoorlie	Gold	2	140	0	0
Collie	Coal	1	15	0	0
Victoria					
Bendigo group	Gold	36	632	0	0
Wonthaggi	Coal	1	374	0	0
Northern Territory					
Marranboy	Tin	1	10†	0	0
Tasmania:					
Mt. Nicholas and Cornwall	Coal	2	18	0	0
Queenstown and Gormanston	Copper, silver	2	44	0	0
Derby, Branxholm, and Weldborough	Tin	3	30	0	0
Zeehan	Silver, lead	1	16	0	0
Waratah	Copper, silver	1	18	0	0
Papua:					
Dubuna‡	Copper	1	61	28	45.9
Laloki‡	Copper	1	84	36	42.9
Misima Block 10‡	Gold	1	434	316	72.8
Total		126	8,908	920	10.3

* In this column "miners" often include mine employees working on the surface.

† Estimated.

‡ Native labor.

In table 1 are shown the results of the examinations of Australian mines up to September 1, 1922. An investigation of the Cloncurry (Queensland) group of copper, silver and gold-mines were attempted but most of them were closed at the time. Nevertheless, 1299 persons including many former miners, were examined in this region, and no locally contracted cases of hookworm disease were found. Examinations of moderate numbers of people including miners were also made at Charters Towers (gold mining) the Bowen coal-mining field, the Kangaroo Hills tin fields, and the Styx coal mines, all in Queensland, and the general conclusion was that hookworm disease was not then prevalent in any of these mines. In North Queensland and New South Wales several important mines remain to be studied.

In all these investigations the examinations of miners for hookworm infection were made by preparing specimens of their feces, using either the centrifuge method or salt-flotation, and then examining for ova under the microscope.

All of the mines in table 1 shown to be free from hookworm disease are in regions where there is no infection, or very little, among people working on the surface. Of the infested mines, the Ipswich coal-mines are outside the belt in which hookworm disease can be regarded as endemic among those who stay on the surface, for the examination of 1698 school children in this area revealed only 10 infections, giving an infection rate of 0.69 per cent. The infested coal-mines of the Burrum group are in a coastal belt of high rainfall, and the people engaged in pursuits other than mining are infected to a considerable extent, but not nearly so much as the miners, as is shown in table 2.

Among the many mines examined, the only groups which have been definitely shown to be spreading hookworm disease are the Ipswich and Burrum groups of coal-mines in Queensland. The severity of the infection in these two mine groups cannot be judged from records of absences from work, as, unfortunately, the books kept at the mines do not discriminate between absences due to sickness and the much larger number due to other causes. It is important for the welfare of the industry and the miners that more detailed and complete records should be kept in such mines and be available for studies of industrial diseases.

TABLE 2

Hookworm infection in the Burrum coal area, by occupations

	NUMBER		ADULTS IN OCCUPATION	ADULT MEMBERS OF HOUSEHOLD OTHER THAN MINERS	SCHOOL CHILDREN SIX TO FOURTEEN YEARS	INFANTS TO FIVE YEARS
Miners, infected	186	Examined		144	204	83
		Infected		38	117	15
		Percentage		26.4	57.4	18.0
Miners, non-infected	38	Examined		40	38	13
		Infected		4	14	1
		Percentage		10.0	36.8	7.7
Total miners (underground)	224	Examined	224	184	242	96
		Infected	186	42	131	16
		Percentage	83.0	22.8	54.1	16.7
Mine employees, infected	22	Examined		32	32	14
		Infected		5	16	0
		Percentage		15.6	50.0	0
Mine employees, non-infected	18	Examined		24	15	9
		Infected		3	6	1
		Percentage		12.5	40.0	11.1
Total mine employees (surface)	40	Examined	40	56	47	23
		Infected	22	8	22	1
		Percentage	55.0	14.3	46.8	4.3
Townspeople, infected	13	Examined		20	13	3
		Infected		6	10	1
		Percentage		30.0	76.9	33.3
Townspeople, non-infected	42	Examined		65	33	32
		Infected		8	6	1
		Percentage		12.3	18.2	3.1
Total townspeople	55	Examined	55	85	46	35
		Infected	13	14	16	2
		Percentage	23.6	16.5	34.8	5.7
Farming people, infected	14	Examined		15	26	7
		Infected		6	18	0
		Percentage		40.0	69.2	0

TABLE 2—*Continued*

	NUMBER		ADULTS IN OCCUPATION	ADULT MEMBER OF HOUSEHOLD OTHER THAN MINERS	SCHOOL CHILDREN SIX TO FOURTEEN YEARS	INFANTS TO FIVE YEARS
Farming people, non-infected....	15	Examined		27	11	4
		Infected		2	3	0
		Percentage		7.4	27.3	0
Total farming people.....	29	Examined	29	42	37	11
		Infected	14	8	21	0
		Percentage	48.3	19.0	56.8	0

One criterion by which the effects of hookworm disease in these mines might be judged is the amount of anemia as shown roughly by the hemoglobin percentage according to the Tallqvist hemoglobin scale. The examination of 13 non-infected miners of the Ipswich group gave hemoglobin percentages ranging from 80 to 95 per cent and averaging 87.1 per cent. The corresponding figures for 12 infected miners were 70 to 85 per cent with an average of 80.4 per cent. The difference between these two average percentages, or approximately 7 per cent of the normal, shows a definite reduction in the amount of hemoglobin, presumably largely owing to hookworm disease. None of the cases showed pronounced symptoms and all were able to work. In the Burrum coal-fields the blood of 115 miners was tested by Drs. C. N. Leach and C. P. Rosenthal of the Hookworm Campaign, and the hemoglobin percentages were found to range from 60 to 100 per cent, and the average was 77.5. In this series, miners were examined as they came and non-infected men were included. Seven men had percentages of 60 or 65.

Another measure of the severity of the infection is the determination of the number and species of hookworms present, for experience shows that the larger the average number of worms harbored and the higher the proportion of hookworms of the species *Ancylostoma duodenale* to those of the species *Necator americanus*, the greater is the injury to health. As the infected miners could not spare three consecutive days from work for

complete worm counts, the number of counts made was small and most of them were incomplete. One man who had been a miner in the Burrum coal-fields seven years before was examined in the hospital at Rockhampton, a non-infested area. In three days following the administration of oil of chenopodium he expelled 241 hookworms, all of the species *Necator americanus*. Most of these may have been acquired outside the mines, although the medical officer investigating the case considered the mines the most probable source. At the Ipswich coal-mines it was attempted to make counts at the miners' homes during week-ends, and 11 partial counts were made after the small routine dose of 1.5 cc. of oil of chenopodium. In 7 cases the stools were saved for only twenty-four hours, and in the other 4 for only two days. In 2 of the one-day counts no worms were recovered. In the other 9 counts, 82 worms of the species *Necator americanus* were secured, an average of 9 worms from each individual, probably only a small part of the total number harbored. The evidence from the percentage of miners infected, hemoglobin percentages, and worm counts suggests that the infection is more severe in the Burrum mines than at Ipswich, that the species *Necator americanus* predominates, and that the infection is doing damage to health, although it seldom causes complete incapacity for work.

It is not entirely clear why hookworm disease has not become prevalent in certain mines, for example, the Newcastle-Maitland coal-mines of New South Wales, in which the conditions of temperature, moisture, pollution of the earth, and occasional introduction of infected miners are favorable to the spread of hookworm disease. It is suspected that one of the important factors tending to inhibit the development of hookworm larvae in mine earth is a high content of dissolved mineral salts in the mine waters. In the series of analyses available, acidity was slight or absent in nearly all cases and not sufficient to be an important factor in preventing the development of hookworm larvae.

In the Great Boulder Mine at Kalgoorlie, Western Australia, according to an analysis on record at the mine, the mine water

contains over 120,000 parts of solids per million and several times as much sodium chloride as is found in sea water. This highly mineralized mine water would with certainty inhibit the development of larvae.

In connection with the investigation of the Commission of Inquiry into miners' diseases at Broken Hill, an attempt was made to ascertain whether the salts in the waters of the local mines would inhibit the development of hookworm larvae, as the ten deep mines at Broken Hill were entirely free from hookworm disease.[3] Contrary to expectations thirteen highly mineralized mine waters permitted the development of hookworm larvae in cultures made up of charcoal and feces containing ova, and kept saturated with the water tested. One of the mine waters tested in this way contained 3.4 per cent of total solids. It completely inhibited the development of the larvae when concentrated to double strength by boiling. In this mine water there was included among the salts present a considerable quantity of zinc sulphate. To test further the effect of this salt, cultures were wet with a 4 per cent solution of zinc sulphate. Larvae developed in the charcoal cultures, but over 3.5 per cent of zinc sulphate inhibited development when sand was used instead of charcoal in making the cultures. Development was inhibited completely in cultures wet with 2 per cent sodium chloride solution but larvae were present in large numbers when only 1.5 per cent sodium chloride solution was used. When mine earths were substituted for charcoal in the cultures used in testing the mine waters, the larvae were much fewer in number and sometimes absent.

Twelve mine-water samples from the Newcastle-Maitland coal-fields were examined for the Hookworm Campaign by the New South Wales Department of Public Health, through the courtesy of the Director-General of Public Health. With one exception, the 12 samples had a high content of mineral salts, and in most instances sodium chloride was the predominant salt. If 2 specimens not typical of this group of mines are excluded, the specimens range in their content of total solids from 2187 to 20,620 parts per million, and in content of sodium chloride

from 1041 to 17,140 parts per million. All but 3 of these samples were alkaline. One of the excluded samples was highly acid.

Six samples of mine waters from the infested mines were analyzed—3 from the Ipswich fields and 3 from the Burrum fields. They ranged in total solids from 470 parts per million to 6943 parts. In sodium chloride content they ranged from 325 to 3003 parts. None of the 6 waters from infested mines had more than 0.7 per cent of total solids and 0.3 per cent of sodium chloride, while eleven out of twenty-one of the waters from non-infested mines exceeded one or both of these amounts. The evidence fails to show that the salt content or reaction of the non-infested mines is alone responsible for the absence of hookworm infestation, as a considerable number of these mines have waters with relatively low amounts of total solids and sodium chloride, and low acidity or alkalinity.[4]

It seems possible that in many cases the dissolved mineral salts, although insufficient in amount to prevent completely the development of hookworm larvae in laboratory cultures, may have a slight deleterious influence which would favor the gradual disappearance of an infestation, thus tending to keep certain of the mines free from hookworm disease. It seems probable that several factors other than the contents of the mine waters enter into the problem and will be necessary to the explanation, except in those few cases where the mine waters are highly above the average in salinity or very acid.

CONTROL MEASURES IN MINES

The control of hookworm disease in Australian mines would not be difficult. The total number of underground workers in the two infested groups of coal-mines is only about 1300, and most of these are in the more lightly infested of the two groups. At the beginning of the investigation nearly all the infested coal-mines, and some of the non-infested ones, were without underground latrines, and the men defecated in the unused workings. In metalliferous mines underground latrines are usually found

[4] The analyses are given in full in Survey Report No. 19 of the Australian Hookworm Campaign.

and there is provision for taking the full pans to the surface. There is a prevalent belief, however, that such care is not necessary in coal-mines, and this is reflected in the policies of the State Mines Departments. In Queensland a number of new underground panstead cabinets with lids have recently been installed in the Burrum Shire group of mines. The Queensland State Department of Mines has sent letters to the operators of coal-mines calling attention to the need for one latrine pan and seat with a supply of deodorant for every 20 men working underground in the infested coal-mines. The Department recommends that the pans should be on a cement flooring and should be protected from overhead drip. The seats should be cleaned at least once a week and the pans should be covered with a tight cover and taken to the surface for emptying not less often than once in two days. The recommendations state also that provision should be made to prevent the miners from working underground with bare feet or leaky boots. This last advice is highly important for many of the coal-miners in the infested group worked barefoot and barebacked, as shown in figure 1. The bare back is probably not nearly so dangerous as the bare feet as most of the infection would come from the floors of the workings.

In addition to circularizing the mine operators the Queensland Department of Mines has printed and distributed a cloth placard for the information of miners. The Australian Hookworm Campaign has treated all the miners found to be infected, but it is inevitable that a considerable proportion will be reinfected and will require further treatment before the preventive measures are fully effective.

TILLING THE SOIL

The statement of Smillie, previously quoted, that hookworm disease is an occupational disease largely limited to soil workers was based in part on four sets of investigations of the numbers of worms harbored by people in rural Brazil and the percentages of hemoglobin in their blood. His data were presented in four tables which have been condensed into table 3 for purpose of comparison.

The figures given in table 3 clearly support Smillie's contentions, as far as the areas investigated are concerned, for the field workers harbored on the average ten times as many hookworms as the others.

FIG. 1. MINER WORKING BAREFOOT AND STRIPPED TO THE WAIST IN THE BURRUM COAL MINES

TABLE 3

Results of investigations by Smillie of severity of hookworm disease in rural districts of Brazil

	NUMBER PEOPLE EXAMINED	AVERAGE AGE	AVERAGE HEMOGLOBIN PERCENTAGE	AVERAGE NUMBER OF HOOKWORMS
		years		
Adult field workers	171	26	63	273
Men doing other work	26	39	72	32
House workers	84	30	69	29
Children working in fields	60	12	56	234
Children not working in fields	66	9	65	20

In the regions studied in Brazil, according to Dr. Smillie's report, children commonly commence working in the fields at the age of eight, the girls beginning a little later than the boys. Nearly all of the field laborers work barefoot, and for long hours. They have no latrines at their homes. In Australia, on the other hand, in the warmer rural districts, most children and a few adults go barefoot by preference as well as for economy, but most of the adults wear shoes even when working. Children are required to go to school until they are fourteen years of age. Moreover, practically every home has a latrine of some sort. Under these conditions, in the white population of rural districts and small towns in infected parts of Queensland, the ratio of the rate of infection in school children (mostly barefoot) to that of adults (mostly wearing boots) was found to be on the average approximately 100 to 57.

In table 4 is shown the prevalence of hookworm disease among white people (almost the whole population), grouped by occupation, in several rural districts in Queensland and New South Wales.

From table 4 the conclusion can be drawn that hookworm disease in the white population of Australia is about 50 per cent more prevalent among children of school age than among agricultural workers, and that it cannot in general be classed as an industrial disease related to tilling the soil. There is abundant evidence, however, in the records of the Hookworm Campaign to show that hookworm disease is a rural disease, even if not usually an occupational disease related to farming, and is relatively infrequent in the cities and larger towns. The most important single factor, however, in the localization of hookworm disease in the Australian tropics and subtropics has been the variations in the amount of rainfall, for hookworm disease practically disappears from the Australian white population where the average annual rainfall is less than 40 inches.

The infection rates in table 4 are for large areas and the farming groups include some kinds of agricultural work requiring relatively little intensive cultivation of the soil. In table 5 are given similar data collected by Dr. C. L. Paine, of the staff of

TABLE 4

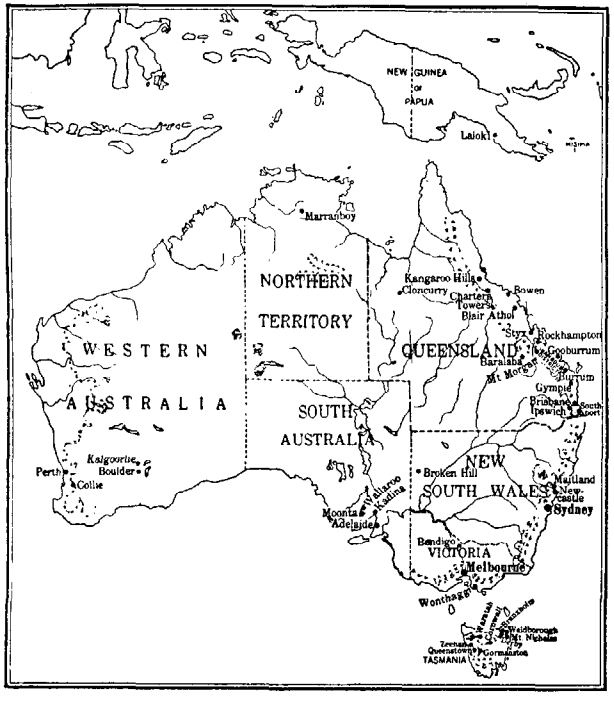
Hookworm disease in rural Australia, by occupations

		BOWEN DISTRICT,* QUEENSLAND	SOUTHPORT DISTRICT, QUEENSLAND	NAMBOUR DISTRICT, QUEENSLAND	NORTHERN RIVERS, NEW SOUTH WALES	TOTAL
School children (six to fourteen years)	Examined	1,116	2,024	3,105	1,234	7,479
	Infected	136	103	163	68	470
	Percentage	12.2	5.1	5.2	5.5	6.3
Infants (one to five years)	Examined	574	901	1,484	545	3,504
	Infected	26	16	33	11	86
	Percentage	4.5	1.8	2.2	2.0	2.5
Domestic duties	Examined	1,313	2,364	3,445	1,423	8,545
	Infected	73	47	61	28	209
	Percentage	5.6	2.0	1.8	2.0	2.4
Farmers and laborers	Examined	994	1,184	2,543	712	5,433
	Infected	102	47	61	20	230
	Percentage	10.3	4.0	2.4	2.8	4.2
Business and professional	Examined	267	357	337	581	1,542
	Infected	5	7	1	13	26
	Percentage	1.9	2.0	0.30	2.2	1.7
Skilled trades	Examined	168	280	293	248	989
	Infected	6	1	5	10	22
	Percentage	3.6	0.36	1.7	4.0	2.2
Miscellaneous and unclassified	Examined	238	390	1,406	130	2,164
	Infected	9	18	30	6	63
	Percentage	3.8	4.6	2.1	4.6	3.0
Total	Examined	4,670	7,500	12,613	4,873	29,656
	Infected	357	239	354	156	1,106
	Percentage	7.6	3.2	2.8	3.2	3.7

* The Districts referred to in this table are large areas usually named after a central town in which the Field Unit of the Hookworm Campaign had its headquarters.

the Australian Hookworm Campaign, for a small area in which sugar-cane is raised.

In table 5 it will be noticed that children (including infants) and wage-earning adults in a sugar-raising community in Queensland were about equally infected, but that those engaged in domestic duties were less infected. If the infants (one to five



years of age) had been classified separately, the children would undoubtedly have shown a higher percentage of infection than the agricultural workers as a group. In table 2 data were given for a community in which agriculture and mining were going on side by side. From this table it will be seen that the children of farmers have a higher infection rate than the farmers themselves, the usual experience in Queensland. The children of

miners, on the other hand, had a lower infection rate than the miners working in infested mines. The children of the mining and agricultural groups were about equally infected. This

TABLE 5

Hookworm infection in Gooburrum Shire, Queensland, by occupations

GROUP	WAGE-EARNING ADULTS			OTHER ADULTS IN HOUSEHOLDS			SCHOOL CHILDREN AND INFANTS			TOTAL		
	Examined	Infected	Percentage	Examined	Infected	Percentage	Examined	Infected	Percentage	Examined	Infected	Percentage
Farm group:												
Farmers and farm laborers	163	3*	1.9	119	3	2.5	188	5‡	2.7	470	11	2.3
Cane-cutters	71	6	8.5	34	0	0	62	3§	4.8	167	9	5.4
Total for group	234	9	3.8	153	3	2.0	250	8	3.2	637	20	3.1
Mill employees:												
Total for group	110	3	2.7	59	0	0	119	3	2.5	288	6	2.1
Town group:												
Total for group	33	1	3.0	25	1	4.0	36	0	0	94	2	2.1
Floating population:												
General	33	0	0	10	0	0	2	0	0	45	0	0
Field workers (cane, etc.)	55	0	0	0			0			55	0	0
Total for group	88	0	0	10	0	0	2	0	0	100	0	0
Miscellaneous:												
Total for group	8	0	0	3	0	0	2	0	0	13	0	0
Total	473	13	2.7	250	4†	1.6	409	11	2.7	1,132	28	2.5

* Including one boy at work, age not specified.

† All four were housemaids from thirteen to seventeen years of age, and three had come from farms.

‡ Three were children of a non-infected farmer, one was the child of another non-infected farmer, and one of an infected farmer.

§ All three in the family of a cane-cutter who was not infected.

suggests that, as a general rule, the children in Queensland get most of their infection near the home and at other places where they congregate to play barefoot, while the farming parent loses

more worms than he acquires, partly because he wears boots much of the time and partly because the fields are less polluted than the closer vicinity of the rural home. The same table shows that the children and adults of the small towns are less infected than those of the country. This is most probably due to the somewhat lessened soil pollution in the town and the greater inclination to wear shoes for the sake of appearance. Boys have been noticed to have more infection than girls, for the older girls are more inclined to wear shoes than their brothers of the same age.

In making these comparisons infection rates have been used, for, where the infection rate is low and based on large numbers of examinations, it is more reliable and more sensitive to moderate influences affecting the transmission of hookworm disease than an index based on the average number of hookworms harbored by the infected individuals. In the mines of the Burrum fields, where the infection rate was high, a knowledge of the average number of hookworms would have been valuable and further attempts are being made to secure this information. In most of the infested areas in Australia, however, less than one-fourth of the people are infected and counts of the hookworms harbored by patients selected on account of moderate pallor or an unusual number of ova, in the stools, or for other reasons, usually show few worms, although rarely a count of several hundred is obtained. Under these circumstances the worm index for an area (average number of hookworms harbored) is difficult to determine, and is of little value for purposes of comparison even if the number of people having no bookworms is considered in computing the index. For these reasons control measures, in the infested areas of Australia, including the prevention of soil pollution and the treatment of infected persons, are being determined and guided by a hookworm index, which is the infection rate of the whole white population of each area. The rates of special groups, such as school children, are corrected for age by means of a simple table.[5] Where thorough control is practicable, such an

[5] Sawyer, W. A., Some directions in which advances in preventive medicine could be made in Queensland, Reprint from Medical Journal of Australia. February 11, 1922, vol. 1, 9th year, pp. 141–144.

index is valuable, as it is highly sensitive to reinfections and can be permanently lowered only by keeping down new infections. On the other hand, where such control is impracticable the highest degree of relief of a heavily infected population would probably be aided best by watching closely the variations in the average numbers of worms harbored.

The need for the treatment of highly infected population groups, such as the agricultural groups considered in this paper, has been questioned by some workers in more highly infested countries. In Australia the evidence seems to show that light infections are deleterious and justify thorough control measures. For example, the work of Waite and Neilson[6] showed that the retardation of mental development was definite even in moderately infected children of Queensland. In some very heavily infested countries it may be necessary to limit treatment at first to the most heavily infected occupational groups, but in Australia the public has already health standards sufficiently high to make it unwilling to permit the steady slight damage from hookworm disease to continue, even when the amount of injury is compatible with moderate laboring efficiency.

CONCLUSIONS

1. Hookworm disease is an occupational disease related to mining in two groups of Australian coal mines, but is absent from most of the mines of Australia. A few of the non-infested mines appear to be protected by the salinity of their waters.

2. In Australia hookworm disease cannot, at the present time, be regarded as an occupational disease related to tilling the soil.

3. Hookworm disease in rural Australia is largely limited to areas having over forty inches of annual rainfall, and involves chiefly the school children, affecting the agricultural workers to a lesser extent.

[6] Waite, J. H., and Neilson, I. L., A Study of the Effects of Hookworm Infection upon the Mental Development of North Queensland School Children, the Medical Journal of Australia, vol. 1, 6th year, pp. 1–8 January 4, 1919.

CONCLUSIONES

1. La uncinariasis es una enfermedad ocupacional con relación a dos de los grupos de las minas carboníferas de Australia, pero no existe en la mayor parte de los campos mineros. Varias de las minas sin infestación parecen estar protegidas por la salinidad de las aguas.

2. La uncinariasis en Australia no puede considerarse como enfermedad de ocupación relacionada con la agricultura.

3. La uncinariasis en la Australia rural está limitada a aquellas areas que tienen una caída de agua anual de mas de cuarenta pulgadas, afectando generalmante a los niños de escuela y en menor grado a los agricultores.